Characteristics of soil salinity in the typical area of Yellow River Delta and its control measures

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Abstract. The Yellow River Delta is one of important ecological areas in eastern China, however sustainable development of the Yellow River Delta is seriously restricted because of severe soil salinization. The main sources of soil salinity are chloride, sodium and sulfate ions. The distribution of soil salinity in soil profiles showed that surface accumulation of soil salt was significant in the Yellow River Delta. Some control measures including soil improvement and regulation, reasonable combination of salt-fresh water irrigation in farmland, land cover and effective drainage were put forward for soil salinity control.

1. Introduction

The Yellow River Delta has been formed by the sediment materials carried with the Yellow River, which is the youngest large alluvial plain in the world [1]. The Yellow River Delta is one important ecological area in eastern China, and it provides the good condition for the development of ecological, efficient and sustainable industry because of the abundant natural resources, unique ecosystem and good development foundation [2-5]. However, over 90 percent of the land area of the Yellow River Delta has been affected by soil salinization with different degrees of severity [6-10]. Sustainable development of the Yellow River Delta is seriously restricted because of severe soil salinization. The objective of this study was to study spatial distribution of soil salinity in the typical area of the Yellow River Delta. Some control measures including soil improvement and regulation, reasonable combination of salt-fresh water irrigation, land cover and effective drainage were put forward in order to control soil salinity.

2. Materials and methods

2.1. Studying area

The studying area is situated on the south bank of the Bohai Bay and the west coast of Laizhou Bay (117°31'-119°18'E; 36°55'-38°16'N). The Yellow River Delta belongs to the warm temperate semi-humid monsoon climate zone with annual average precipitation of 593.6 mm, over 50% of which occurs in July and August. Annual average evaporation is 1944 mm and precipitation-evaporation ratio is 3:1. The annual average temperature is 12.5°C. The capillary uplift strength of the soil is higher than that of the gravity downstream flow, which can create favourable conditions for salt accumulation in the soil surface. The groundwater in the Yellow River Delta is generally shallow (average depth of about 1m). The degree of mineralization is generally high, and the average degree of

mineralization greater than 10 g/L, which mostly belongs to salt water and brackish water. As the groundwater is shallow, the salt in the groundwater can easily accumulate to the surface through the rising force of the capillary, forming soil salinization.

2.2. Soil sampling

The soil samples of the typical area of Yellow River Delta were sampled to analyse soil salinity in different depth soil layers (0-100 cm) in May 2015. In sampling sites, surface plants and stone pieces and other shovel were firstly removed, and then a 100 cm depth rectangular pit was dug. The soil profile was divided into five layers (0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, and 80-100 cm) and soil samples were collected from the bottom layer to top. The soil was air dried in the room, passed through 1mm sieve, and prepared for soil water extract solution (1:5 soil/water ratio) for the measurement of soil salinity. 50 g soil was added into plastics bottle with 250 mL deionized water, and shaked for 3 min, and then filtered with 0.45 um filter paper to get clean leachates. In April 2016, 180 sampling points were sampled from surface soil (0-20cm) in the Yellow River Delta and analysed the distribution characteristics of surface soil salinity. A handheld GPS locator was used to obtain the coordinates and recorded the vegetation type and the surrounding environment of sampling points.

2.3. Soil sampling

The electrical conductivity (Ec) of the soil leachate was determined by conductivity meter and the total amount of salt (soil salinity) was calculated accordingly. The cations of soil leachate were measured by atomic absorption spectroscopy. The concentration of sulfate was measured by ion chromatography and UV/VIS spectrophotometer. The concentration of chloride ion was determined by $AgNO_3$ titration method. Based on the soil salinization classification standard, soil salinity can be divided into five classes (Table 1).

Table 1. Classification standard of soil salinity

Soil salinity (g/kg)	Degree of soil salinization	Response of plants
<1	non salinized	no salt damage to the plant
1-3	mild salinized	salt-sensitive plants may be affected
3-5	moderate salinized	have an impact on salt-sensitive plants, but salt-tolerant plants still grow well
5-10	strong salinized	only salt-resistant plants can grow well
>10	saline soil	only few salt-resistant plants can grow

3. Results and Discussions

3.1. Results

Based on the experimental results of 33 soil profile samples and 181 surface soil samples salinity analysis, the basic situation of soil salinity in the Yellow River Delta was obtained. From the basic composition of soil soluble salt ions, it can be seen that the main sources of soil salinity in the Yellow River Delta were chloride, sodium and sulfate (chlorine and sulfate accounts for more than 50% of total salt). According to the classification standard of soil salinity, there were 53 samples of non-salted soil (total salt content <1 g/kg) in the study area (accounting for 29% of the total samples), and saline soil accounted for about 71% of the total samples. It indicated that most of the soil samples in the Yellow River Delta belonged to saline soil and had a higher degree of salinization.

The soil salinity of soil profiles in the Yellow River Delta was measured by the salt analysis of 0-100 cm depth soil. It showed the soil salinity maximum (48.71g/kg) and the mean (6.21 g/kg) in 0-20 cm soil layer, salinity maximum (31.71 g/kg) and mean (4.06 g/kg) in 20-40 cm soil layer, salinity maximum (28.12 g/kg) and mean (3.80 g/kg) in 40-60 cm soil layer, salinity maximum (21.7 g/kg) and mean (3.09 g/kg) in 60-80 cm soil, salinity maximum (21.80 g/kg) and mean (3.39 g/kg) in 80-100 cm

soil. It can be seen that the maximum and mean values of salt content in the surface soil were much higher than those of the salt content of the bottom soil, and the difference between the salt content of the surface soil and the bottom soil can reach more than 40 times, which fully explained the soil salt accumulation in soil profile was significant in the Yellow River Delta. Distribution of total salt and Cl concent and of the soil profiles in four typical sites in Yellow River Delta is shown in Fig.1.

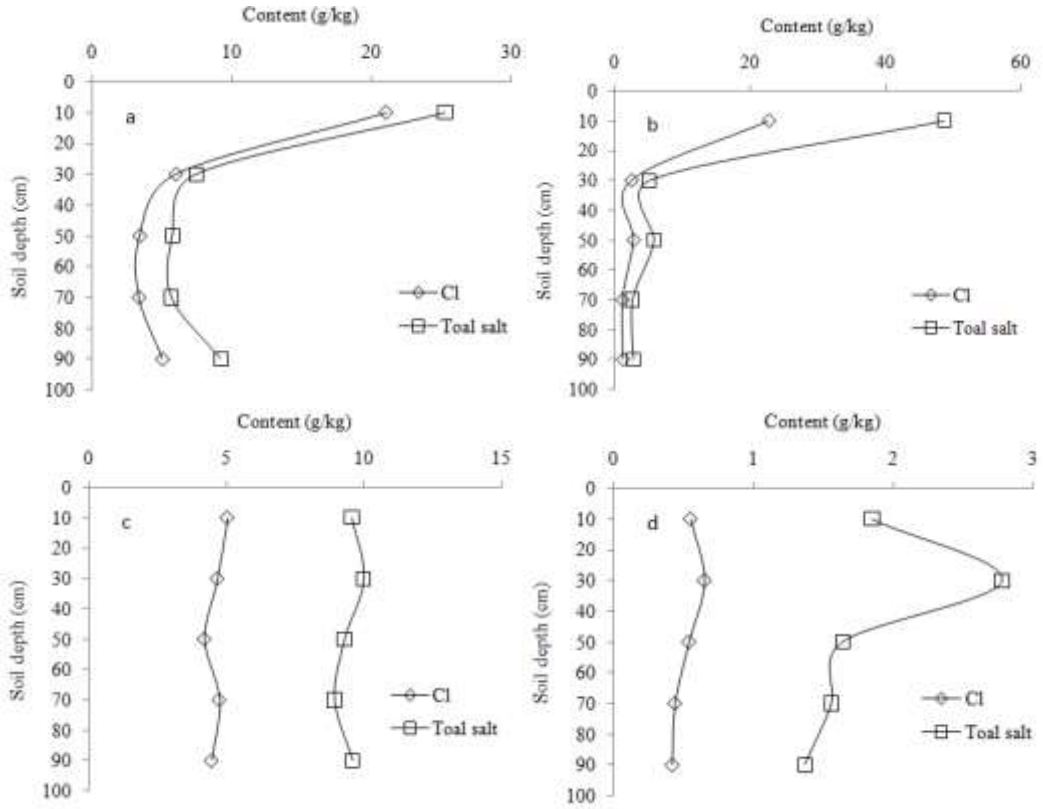

Figure 1. Distribution of total salt and Cl concent of soil profiles in four typical sites (a. Wuhaozhuang, b. Yellow River Delta Geopark, c. Diaokou, D. Yuwa) in Yellow River Delta.

3.2. Discussions

Based on the results of soil salinty in the typical area of Yellow River Delta, some soil salinity control measures were discussed as follows.

(1) Soil improvement and regulation. Chemical improvement measures include the application of amendment substrates such as calcium sulfite, gypsum, phosphogypsum. Biological improvement measures include the cultivation of salt-tolerant plants and pastures, green manure, afforestation and so on. Through fertilization measures (planting green manure, etc.) to supplement and improve soil organic matter and nutrient content, soil structure and physical and chemical properties can be improved.

(2) Measures for improvement of water conservancy. The main fresh water source is Yellow River in the Yellow River Delta, and water supply capacity is very limited. So the use of groundwater as an important measure is very important to alleviate the water crisis. However, groundwater is mainly salt water or brackish water n the Yellow River Delta, the combined irrigation method using brackish water and fresh water during irrigation time is recommended in farmlad of the Yellow River Delta. Many studies have found that the use of various combination irrigation methods (e.g. brackish-fresh water, fresh-brackish-fresh water) was conducive to surface salt leaching or even discharged from soil layer. Although brackish water irrigation will increase the salt content of the soil, fresh irrigation can play the role of salt leaching under the reasonable combination of brackish and fresh water irrigation,

and the salt content of the surface soil can reduce and maintain the crop normal growth. Soil salinity will not cause significant accumulation through the combination irrigation of fresh water and brackish water, plus the rainy season of concentrated leaching salt effect.

(3) Surface covering. Evaporation can affect the redistribution of soil moisture and salinity to a large extent. Ground cover measures can reduce soil surface evaporation. Many studies have found that straw cover or plastic film cover can effectively reduce the evaporation and play a role in water conservation, which can effectively reduce the salt content of surface soil compared with no coverage measures. It was reported that the salinity content of 0-40 cm soil layer using wheat straw cover was reduced by 12.41% than that of control treatment, and it showed that the covering treatment played a good role in the regulation of soil salinity [11].

(4) Drainage. Drainage is one primary method of controlling soil salinity. Effective discharage of excessive salt from soil is one of the important regulatory measures. Pipe drainage technology in the control of salt performance is very good which can quickly remove surplus of water in the soil, reduce the groundwater level to prevent the salt back to soil, and create a good environment for crop growth.

4. Conclusion

Sustainable development of the Yellow River Delta is seriously restricted because of soil salinization. The results showed that saline soil accounted for about 71% of the total samples. The main sources of soil salinity in the Yellow River Delta are chloride, sodium and sulfate ions (chlorine and sulfate accounts for more than 50% of total salt). Surface accumulation of soil salt in soil profile was significant in the Yellow River Delta. Some control measures including reasonable combination of salt-fresh water irrigation, land cover and effective drainage were put forward in order to control soil salinity.

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References

[1] Z.R.Wang, G.X. Zhao, M.X. Gao, C.Y. Chang, Spatial variability of soil salinity in coastal saline soil at different scales in the Yellow River Delta, China, Environmental Monitoring and Assessment. 189 (2017): 80.

[2] Y.W. Qin, G.X. Zhao, J. Wang, J. N. Cheng, Y. Meng, C. Dong, T.Lei, Restoration and reutilization evaluation of coastal saline-alkaline degraded landsin Yellow River Delta. Transactions of the Chinese Society of Agricultural Engineering. 25(2009) 306-311.

[3] X. Fan, B. Pedroli, G. Liu, Q. Liu, H. Liu, L. Shu, Soil salinity development in the yellow river delta in relation to groundwater dynamics, Land Degradation & Development. 23(2012), 175-189.

[4] B.H. Li, G.X. Zhao, C.Dong, Y.W. Qin, Dynamic and driving force analysis of salinized land in the Yellow River Delta based on RS and GIS, Journal of Natural Resources. 26(2011), 310-318.

[5] Z.R. Wang, G. X. Zhao, M.X. Gao, C.Y. Chang, S.Q. Jiang, J.C. Jia, J.Li, Spatial variation of soilwater and salt and microscopic variation of soil salinity in summer in typical area of the Yellow River Delta in Kenli County, Acta Ecologica Sinica. 36(2016), 1040-1049.

[6] J.S. Yang, R.J.Yao, Spatial variability of soil water and salt characteristics in the Yellow River Delta, Scientia Geographic Sinca. 27(2007), 348-353.

[7] J.B. Yu, Y.Z. Li, G.X. Han, D. Zhou, Y.Q. Fu, B. Guan, G.M. Wang, K. Ning, H.F. Wu, J.H. Wang, The spatial distribution characteristics of soil salinity in coastal zone of the Yellow River Delta, Environmental Earth Sciences. 72 (2014): 589-599.

[8] Q. Liu, G. Liu, X. Fan, Temporal-spatial distribution of soil salinity profile types in the Yellow River Delta, Shandong Agric Sci. 1 (2010):57-62.

[9] Y. Guan, G. Liu, Q. Liu, Q. Ye, The study of salt affected soils in the Yellow River Delta based on remote sensing. J Remote Sensing. 5(2001): 46-52.
[10] R.J. Yao, J.S. Yang, G.M. Liu, P. Zou, Spatial variability of soil salinity in characteristic field of the Yellow River Delta, Transactions of the Chinese Society of Agricultural Engineering. 22(2006), 61-66.
[11] H.C. Pang, J.S. Yang, H.J. Yan, Effects of irrigation with saline water on soil salinity and crop yield, Plant Nutrition and Fertilizer Science. 10(2004): 599-603.